

SOLPS5 modelling of the ELMing H-mode on TCV

B. Gulejová^a, R. A. Pitts^a, R. Behn^a, D. Coster^b, J. Horacek^a, J. Marki^a, M. Wischmeier^b

^a CRPP-EPFL, Association EURATOM-Confederation Suisse, CH-1015 Lausanne, Switzerland

^b Max-Planck Institut für Plasmaphysik, EURATOM-Association, Boltzmann Str.2, D-85748, Garching, Germany

Tokamak à Configuration Variable



R=0.875 m, a=0.25 m, B_φ = 1.43 T
 All-graphite machine
 Number of open diverted configurations
 Standard operating mode with reversed toroidal field B_φ
 => ion B × ∇B drift direction upwards

Scrape-Off Layer Plasma Simulation

SOLPS 5 = coupled EIRENE + B2.5

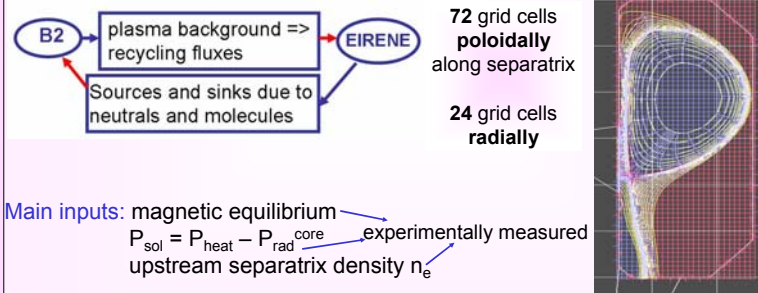
Suite of codes to simulate transport in edge plasma of tokamaks

B2 - solves 2D multi-species fluid equations on a grid given from

magnetic equilibrium

EIRENE - kinetic transport code for neutrals based on

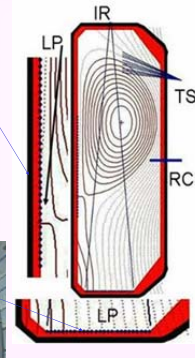
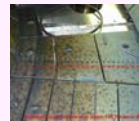
Monte - Carlo algorithm



Main inputs: magnetic equilibrium
 $P_{sol} = P_{heat} - P_{rad, core}$ experimentally measured
 upstream separatrix density n_e

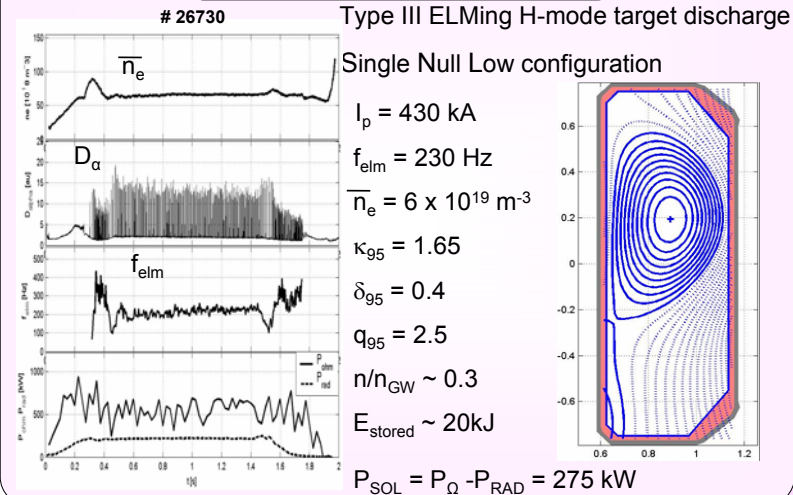
Parameters: cross-field transport coefficients (D_{\perp} , χ_{\perp} , v_{\perp}) systematically adjusted until agreement of simulation with experiment is achieved

Edge diagnostics in TCV



- Targets**
- LP : Langmuir probes
 → j_{sat} , T_e , n_e at the targets
 - IR: fast Infrared thermographic camera
 → perpendicular heat flux at outer target
- Upstream**
- RCP: fast reciprocating Langmuir probe
 → T_e , n_e upstream
 - TS: edge Thomson scattering system
 → T_e , n_e upstream

Typical ELMing H- mode



Inter-ELM simulation Ansatz

SOL radial **heat flux**: $q_{\perp} = -(n\chi_{\perp} \frac{dT}{dr} + 5T(D_{\perp} \frac{dn}{dr} + nv_{\perp}))$

SOL radial **particle flux**: $\Gamma_{\perp} = -D_{\perp} \frac{dn}{dr} + v_{\perp}n$

Cross-field radial transport in the main SOL-complex phenomena

$\Gamma_{\perp} = -D_{\perp}^{eff}(r) \cdot \nabla n$ diffusion (D_{\perp}) + convection (v_{\perp})

Direct measurements of turbulent driven ExB radial fluxes using turbulent code ESEL predict very small values of D_{\perp} => More appropriate approach would be 'convective'

(with $D_{\perp} = D_{\perp, collisions}$ and variation of v_{\perp})

However only the value of flux matters for the code and thus we can neglect convective term of equation for simplification and assume $v_{\perp} = 0$

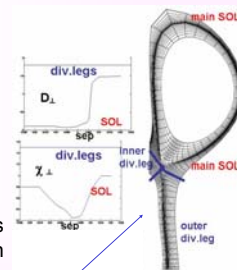
Assumption: $\chi_{\perp i} = \chi_{\perp e}$

Ansatz: D_{\perp} , χ_{\perp} - variation

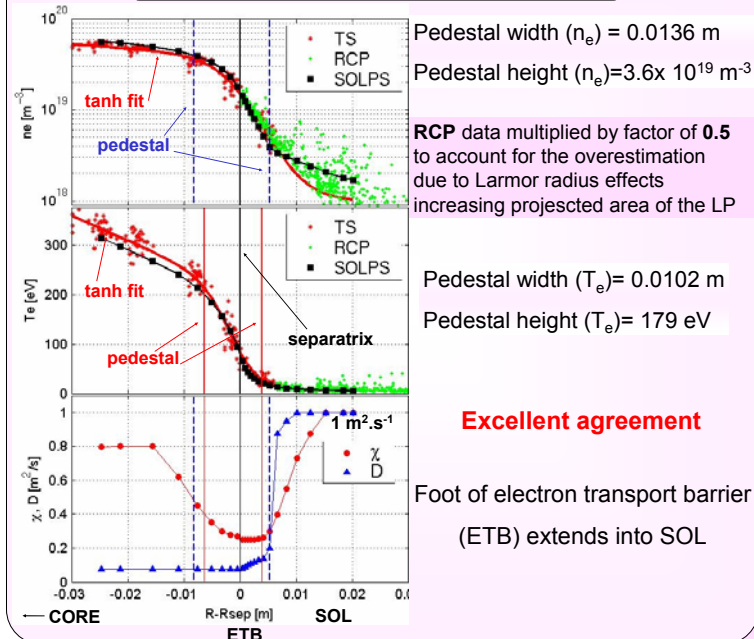
radially - transport barrier (TB)

poloidally - no TB in divertor legs

Transport is specified differently in the main chamber SOL and divertor regions



SOLPS vs experiment upstream

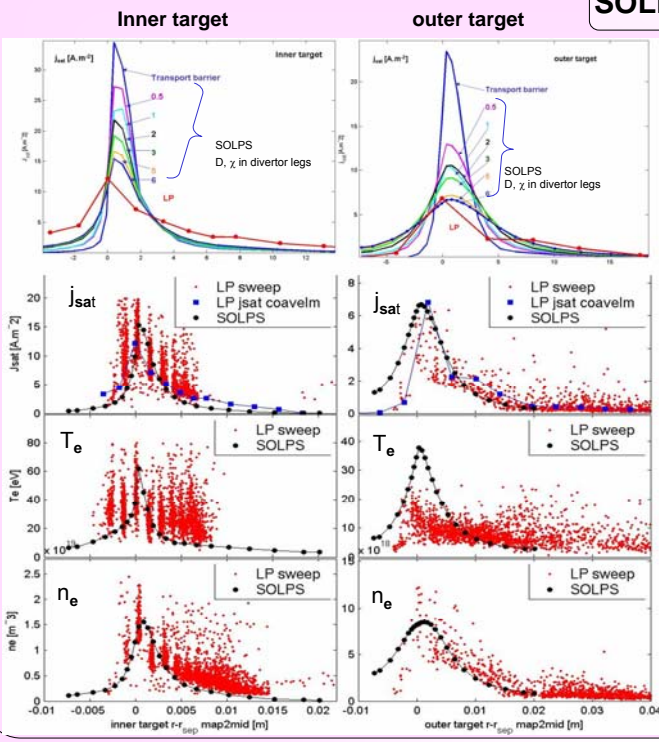


Foot of electron transport barrier (ETB) extends into SOL

SOLPS5 modelling of the ELMing H-mode on TCV



SOLPS vs experiment at the targets

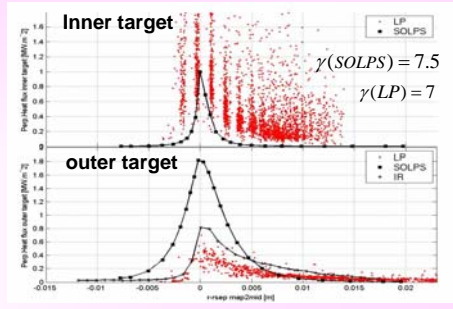


• Match is obtained only by "switching off" the transport barrier in divertor regions and increasing D, χ in divertor legs from $1 \rightarrow 6 \text{ m}^2 \cdot \text{s}^{-1}$ (cf. $1 \text{ m}^2 \cdot \text{s}^{-1}$ in main chamber SOL). Increase of D, χ in inner leg doesn't matter much

• SOLPS models inner target well because it's there probably dominated by geometry of TCV

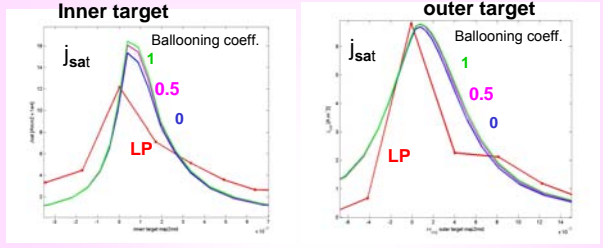
• Discrepancies at outer target might be explained by the fact that DRIFTS are not included in simulations yet

Perpendicular heat flux

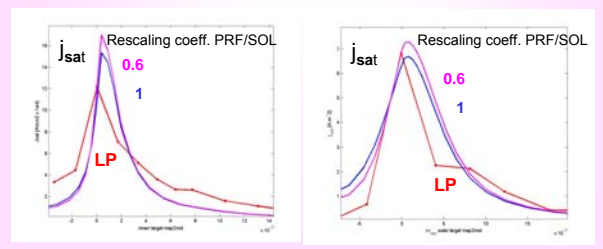


Sensitivity study

Ballooning effect

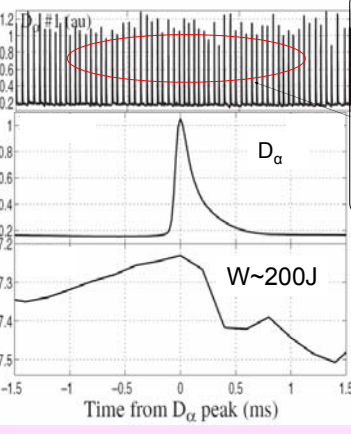


Private flux region vs. SOL

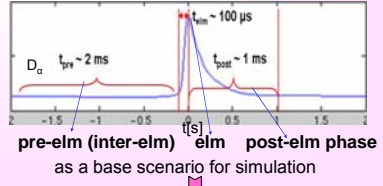


Edge localized mode (ELM) - Coherently averaged ELM

H-mode \rightarrow Edge MHD instabilities \rightarrow Periodic bursts of particles and energy into the SOL
ELM leaves edge pedestal region in the form of a helical filamentary structure localised in the outboard midplane region of the poloidal cross-section



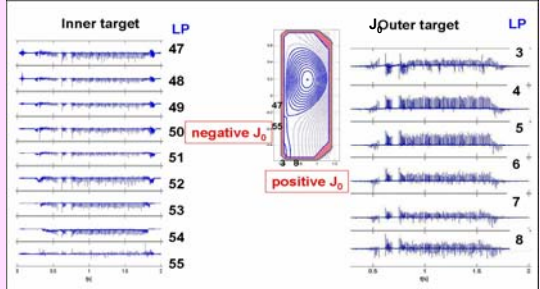
Energy expelled by Type III ELMs at TCV $\sim 200 \text{ J}$
ELMs - too rapid (frequency $\sim 200 \text{ Hz}$) for comparison on an individual ELM basis
Many similar events are coherently averaged inside the interval with reasonably periodic elms



1.step: Inter-ELM simulation

Inner and outer target balance of J_0

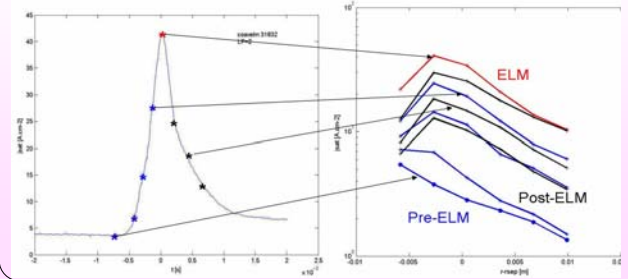
Voltage $V=0$ applied to Langmuir probes



Thermoelectric currents flow from outer to inner (cold to hot) target (see Ref.)

Analysis of LP data based on coherently averaged elm method

ELM-time evolution of j_{sat} at outer target



Simulation of ELM in progress...

